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the forms of erosion assumed by the rocks are shown in numerous illustrations.

The lower half of the rocky slopes of the mountain consists of dark-colored rock eroded into towers and spires, which are strongly contrasted with the light-colored upper half of the mountain, where the rock is in large masses and cliffs. The white rock is sodalite-syenite, already described by Lindgren, the petrographical characters of which are briefly reviewed. The dark rock is a new type of rock consisting of much augite and less orthoclase, besides olivine, biotite, albite, anorthoclase and accessory nephelite, sodalite and other minerals. The chemical composition of the rock, and that of the pyroxene are given, and the mineralogical features of the rock are fully described. The name shonkinite is proposed for the new rock. The two rocks of the laccolite form one mass, erupted at one time; the marked differences between them being the result of differentiation subsequent to their intrusion within the sedimentary rocks. The process of differentiation is discussed at length, and the opinion is expressed that no one simple process will explain all cases, but that a variety of factors must be taken into account, any one or all of which may operate to produce a given phenomenon.

J. P. I.

The Laccolitic Mountain Groups of Colorado, Utah and Arizona. By WHITMAN CROSS. Fourteenth Annual Report of the Director U. S. Geological Survey, for 1892-3. Washington, 1895. 84 pp., 10 Plates, 19 Figures.

Having become familiar with numerous instances of laccolitic intrusions in Colorado, and having noted how much doubt concerning their true nature existed in the minds of some foreign geologists, Mr. Cross has undertaken to present the facts already known of such bodies of igneous rocks, so far as concerns their occurrence in regions explored by himself and in the neighboring regions of Utah and Arizona. And in so doing he has endeavored to establish more clearly the various phases of laccolitic intrusions within sedimentary strata, and to describe the petrographical character of the igneous rocks that constitute such intrusive bodies. The paper first reviews in considerable detail the facts established by Gilbert regarding the laccolites of the Henry Mountains, and the theory he advanced in explanation of them. It also reviews the characters of the rocks from a study of the specimens collected by Gilbert and originally described by Dutton. According

to modern nomenclature the rocks would now be called porphyrites, and the recent study with better thin sections confirms the conclusions of Dutton that the specimens collected from laccolites and dikes indicate no differences of composition or structure corresponding either to geographical or geological distribution, or to the size or form of the intruded masses.

The West Elk Mountains are described and the numerous instances of laccolitic mountain masses noted. Some of these masses were described by Holmes and Peale in reports of the Hayden Survey for 1873 and 1874. They have been more recently studied by Cross. The individual mountain masses of this group consist of homogeneous igneous rock, which in a number of cases is clearly shown to be intrusive within sedimentary strata, and is accompanied by sheets and dikes of the same eruptive rock. The character of the rock is very nearly the same as that of the Henry Mountain laccolites. The microstructures of the rocks of the different masses are practically the same, indicating that even the highest bodies solidified under a great load. The strata in which they have been intruded is Cretaceous, and the age of the intrusion is Tertiary.

The isolated mountain groups of San Miguel, La Plata, Carriso, El Late, Abajo and La Sal, which were studied by Holmes and Peale, are reviewed and their structure noted as that of laccolitic intrusions within nearly horizontal strata. The rocks in all cases are of the same general type of porphyrites. Intrusions within more or less disturbed strata of older age and also within the crystalline schists, which have been studied by Cross, are described. They occur in the Mosquito Range and the Ten Mile District. Here the igneous bodies form sheets and dikes, the rocks having the same general structural characters as in those previously described, but having a somewhat wider range of composition. Other occurrences of similar intrusions within the ranges of the Rocky Mountains are mentioned. In conclusion Cross points out the fact that while the rocks forming these intrusive bodies show considerable variation in composition, the great majority of them belong to one well marked structural type, that of porphyry; and that this is plainly the result of the similarity of conditions of consolidation upon magmas which are much alike in their controlling elements. He adds that there is every reason to suppose that other eruptive provinces may be characterized by intrusive masses of other rock types. If the magma of another region were very different from that so common in the region described, another structural type might

result from the same conditions of cooling. He points out the fact that the rocks of the plateau groups and those of the mountain area of Colorado differ in the relative abundance of alkalies, those of the latter area being higher in potash. These observations apply to all igneous rocks whether in the form of laccolites or not, and the rocks of the Yellowstone Park, whose analyses are placed in a table for comparison with those of the rocks Cross has described, are not laccolitic, but dike-like intrusions. Since Cross wrote this paper Pirsson and Weed explored the Highwood Mountains and published the description of the laccolite of Square Butte, whose rock is granular syenite and shonkinite, very different in structure and composition from the porphyries described by Cross.

In discussing the mineral composition of the rocks Cross lays stress on the fact that in some cases large orthoclase phenocrysts have clearly been crystallized after other constituents which do not appear as phenocrysts. He finds no evidence that any of these eruptive masses "absorbed" sedimentary masses. There is in fact almost no metamorphism of sedimentary rocks along the contact with these igneous bodies.

Owing to the great range in geological distribution and in size and form of masses of practically identical rocks, Cross concludes that the conditions of cooling or consolidation were almost the same throughout a wide (deep) zone, and that pressure as a function of depth has had very little influence within the limits represented. The rate of cooling must have been essentially the same for all masses, indicating that below a certain depth there is a zone in the earth's crust within which conditions of cooling are practically uniform. The upper and lower limits of this zone are not known, but it would seem as if a depth of several thousand feet must be necessary to secure a temperature so high and a rate of cooling so slow that the chilling effect upon an intruded magma should be no greater than that at a depth of 20,000 feet. We do not find that Cross considers the consequences of magmas having quite different temperatures when they reach the place of laccolitic intrusion, or that he discusses possible differences of temperature of the enclosing rocks due to local causes.

In describing the structure of laccolitic rocks, Cross discusses the terms *porphyritic* and *granular*, and expresses the opinion that they should be limited to purely formal ideas, without regard to the possible origin of the structures, and that they should not be confined to megascopic textures, but should be used for the same kinds of structure whether megascopic or microscopic.

As to the forms of laccolites he does not believe in limiting the term to those intrusive bodies only that occupy a perfectly regular position with regard to stratification planes, but would apply it to any intrusive body where the expansion of the body has taken place from a plane even approximately parallel to the bedding. In horizontal strata the lifting of the load by the intrusive force may be taken as the prime essential. The deviations from the type forms from accidental causes are many. With regard to the origin of laccolites Cross cites a number of facts which demonstrate that the horizon occupied by intrusive magmas are not determined by relative densities of the intruding lavas and of the invaded strata, as suggested by Gilbert, and assuming eruptive energy such as exists in active volcanoes he concludes in the words of James D. Dana that "no other cause could be needed for a flow to the surface in case of an open channel, or for a flow to any level in the strata at which a fissure might terminate; and this is true whether the lava be light or heavy."

J. P. I.

Petrology for Students. An introduction to the study of rocks under the microscope. By ALFRED HARKER. Published by Macmillan & Co., New York, 1895. Price \$2.

As the author states in the preface this text-book is prepared especially for English students, nevertheless it will be found very useful for those beginning the study of petrography in this country, who wish a text-book written in English. No systematic account of the crystallographic and optical properties of minerals has been attempted, and for such information the student is referred to the translation of Professor Rosenbusch's volume on the rock-making minerals. But as an introduction to the study of the rocks themselves a number of useful observations of a general nature are presented upon the characters of minerals in thin section, and especially the latest methods of distinguishing the different varieties of feldspar. In treating so complex a subject as the optical properties of minerals in thin sections in such a condensed manner it is doubtful whether the author can meet the wants of a beginner. It serves, however, as a form of definition of the terms used throughout the book. It would seem that in neglecting the use of those methods of determination based on the optical phenomena observed with converging polarized light the author needlessly weakens the processes of petrographical diagnosis.

In his remarks upon the examination of rock sections the author